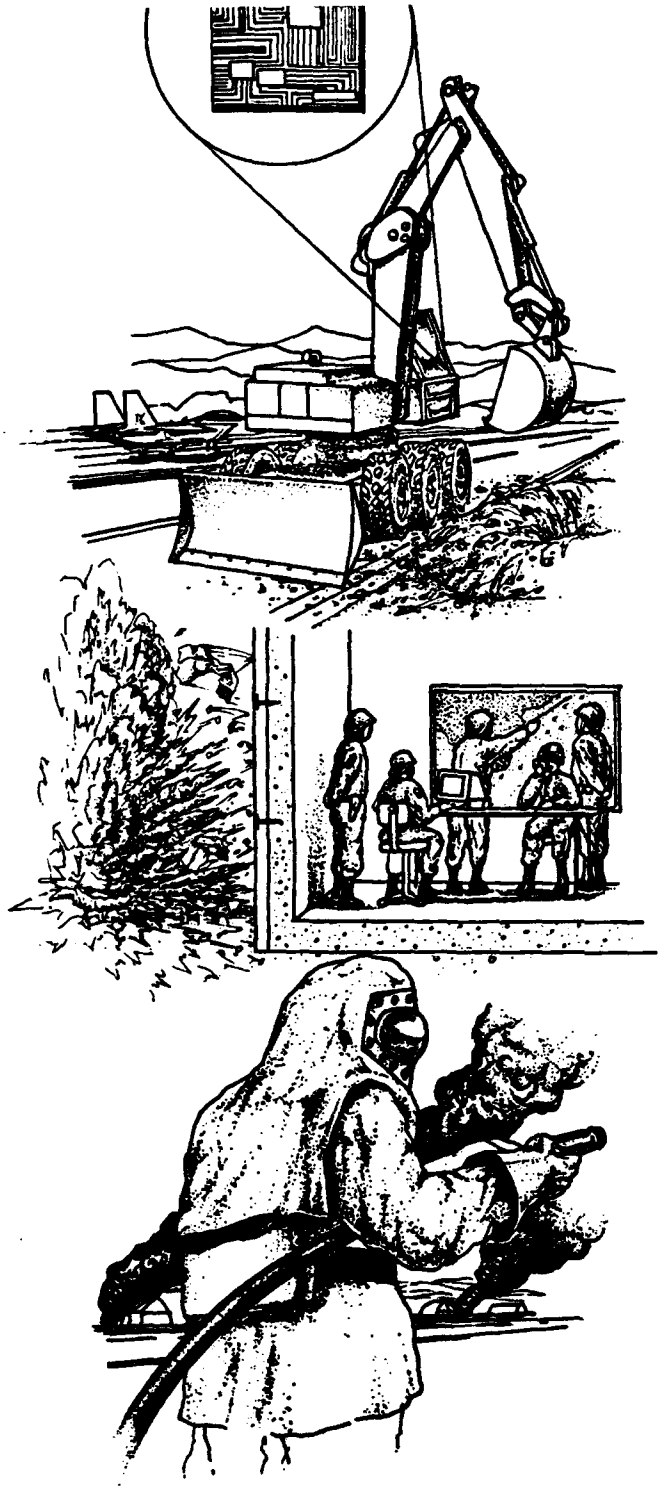

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P-19 PRECISION METERING AND ONE PERCENT AFFF LARGE-SCALE FIRE PERFORMANCE TEST

R. N. VICKERS,
J. H. STORM,
M. J. WILSON

APPLIED RESEARCH ASSOCIATES, INC.
4300 SAN MATEO BLVD., N. E., SUITE A220
ALBUQUERQUE, NM 87110

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FINAL REPORT

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ENGINEERING RESEARCH DIVISION
Air Force Civil Engineering Support Agency
Civil Engineering Laboratory
Tyndall Air Force Base, Florida 32403

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R. N. Vickers, J. H. Storm, and M. J. Wilson

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Applied Research Associates, Inc.
4300 San Mateo Blvd, N. E., Suite A220
Albuquerque, NM 87110

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13. ABSTRACT *(Maximum 200 words)*

This project evaluated the performance of a precision metering system for the P-19 firefighting vehicle and the effectiveness of 1 percent AFFF in fighting large hydrocarbon fires. The metering system was designed, manufactured, installed, and test assistance provided by the Hypro Corporation. This system replaces the around-the-pump inductor foam metering system, originally installed in the P-19, with a modern closed-loop computer-controlled system. The Hypro metering system is a well engineered; metering accuracy is excellent. The primary nozzles of the P-19, roof and bumper turrets, maintain metering at either 1 or 3 percent within the specified tolerance of ± 0.1 for 1 percent and ± 0.3 for 3 percent. One percent AFFF was found to be at least as effective and possibly more effective, than 3 percent AFFF in extinguishing large JP-4 fires.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The overall objective of this test series was to verify the accuracy of the Hypro modified AFFF metering system in the P-19 fire fighting vehicle. The secondary objective was to demonstrate the effectiveness of 1 percent AFFF in extinguishing large hydrocarbon fires.

B. BACKGROUND

The Department of Defense uses AFFF concentrates formulated to be mixed with water in ratios of 3 and 6 percent. A significant operational capability increase will be realized by converting to 1 percent AFFF. Firefighting vehicles will gain a threefold increase in effective agent quantity on-board and require less frequent refilling of the AFFF tank. Converting to one percent AFFF will also result in a considerable costs savings in the shipping and storage of one third of the quantities. In a deployed scenario, the 66 percent reduction in the quantities required and the threefold increase in vehicle firefighting sustainability will pay particularly large military dividends. The Air Force's front line firefighting vehicle, the P-19, is designed to dispense AFFF at a 3 percent AFFF/water ratio. During tests conducted by AFESC during 1988-89 attempts to meter at 1 percent by replacing the orifice plate with a plate with smaller metering holes was unsuccessful. In order for the Air Force to fully realize the benefit of using 1 percent AFFF, the P-19, as well as other Air Force firefighting vehicles, must be capable of accurately metering AFFF at the prescribed 1 percent ratio. With the current commercial availability of 1 percent AFFF, with its inherent cost savings and increased firefighting longevity, the Air Force must have the capability to use this agent.

C. SCOPE

This project evaluated the performance of a precision metering system for the P-19 firefighting vehicle and the effectiveness of 1 percent AFFF in fighting large hydrocarbon fires. The metering system was designed, manufactured, installed, and test assistance provided by the Hypro Corporation. This system replaces the around-the-pump inductor foam metering system, originally installed in the P-19, with a modern closed-loop computer-controlled system.

D. CONCLUSION

The Hypro metering system is a well engineered; metering accuracy is excellent. The primary nozzles of the P-19, roof and bumper turrets, maintain metering at either 1 or 3 percent within the specified tolerance of ± 0.1 for 1 percent and ± 0.3 for 3 percent. One percent AFFF was found to be at least as effective and possibly more effective, than 3 percent AFFF in extinguishing large JP-4 fires.

The Air Force should consider adapting precision metering system technology to retrofit the P-19 fleet, modify new production line P-23 vehicles or retrofit vehicles in the field, and use of 1 percent AFFF in place of 3 percent foam when precision metering systems are operational on CFR vehicles.

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PREFACE

This report was prepared by the Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall Air Force Base, Florida 32403.

Mr. Hugh Pike, AFESC/RDCF, was the Project Officer. This report presents the results of the P-19 Precision Metering Test Program conducted from 4 Oct 1990 to 29 May 1991 at Tyndall AFB, Florida.

This report has been reviewed and is approved.

HUGH A. PIKE
Project Officer
AFESC/RDCF

NEIL H. FRAVEL, Lt Col, USAF
Chief, Engineering Research Division

RICHARD N. VICKERS
Chief, Airbase Fire Protection
and Crash Rescue Systems Branch

FRANK P. GALLAGHER III, Colonel USAF
Director, Engineering and Services
Laboratory

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SECTION I

INTRODUCTION

A. OBJECTIVES

The overall objective of this test series was to verify the accuracy of the Hypro modified AFFF metering system in the P-19 firefighting vehicle. The secondary objective was to demonstrate the effectiveness of 1 percent AFFF in extinguishing large hydrocarbon fires.

Specific objectives are listed in Appendix A.

B. BACKGROUND

The Department of Defense uses AFFF concentrates formulated to be mixed with water in ratios of 3 and 6 percent. A significant operational capability increase will be realized by converting to 1 percent AFFF. Firefighting vehicles will gain a threefold increase in effective agent quantity on-board and require less frequent refilling of the AFFF tank. By using the more concentrated AFFF (1 percent as compared to 3 and 6 percent), which is mixed 1 percent with water, a considerable costs savings in the shipping and storage of one third of the quantities required will also be realized. In a deployed scenario, the 66 percent reduction in the quantities required and the threefold increase in vehicle firefighting sustainability will pay particularly large military dividends.

Common terminology in the fire protection community refers to an AFFF concentrate designed to be mixed with water at a ratio of 3 percent AFFF to 97 percent water as "3 percent AFFF". A "6 percent AFFF" concentrate contains approximately one-half of the surfactant and other active ingredients as 3 percent AFFF concentrate per unit volume and consequently is referred to as, "less concentrated". When mixed with water at their designed ratios either type AFFF/water mixture provides essentially the same firefighting capability.

The Air Force's front line firefighting vehicle, the P-19, is designed to dispense AFFF at a 3 percent AFFF/water ratio. During tests conducted by AFESC during 1988-89 using a typical P-19, the actual mixing ratio varied from 3.0 to 5.9 percent. Attempts to meter at 1 percent by replacing the orifice plate with a plate with smaller metering holes was unsuccessful.

In order for the Air Force to fully realize the benefit of using 1 percent AFFF, the P-19, as well as other Air Force firefighting vehicles, must be capable of accurately metering AFFF at the prescribed 1 percent ratio, within a reasonable tolerance (+10 percent of the required metering ratio). With the current commercial availability of 1 percent AFFF, with its inherent cost savings and increased firefighting longevity, the Air Force must have the capability to use this agent. Ten potential firefighting system metering firms were surveyed in an attempt to obtain an accurate, reliable metering system for the P-19. Only the Hypro Corporation of New Brighton, Minnesota responded with a suitable system. They designed, installed, and tested a precision AFFF metering system that replaced the original around-the-pump metering system in the P-19 firefighting vehicle. The Hypro system incorpo-

rates accurate flow sensors in each agent line (roof turret, bumper turret, and handline) and a central computer that receives input from the flow sensors and controls the positive displacement AFFF pump via a hydraulic control block. Hydraulic power to drive the AFFF pump is taken from the existing power steering pump. A valve that maintains priority to the power steering and a large capacity hydraulic fluid reservoir are also included in the modification. A simple operator interface is maintained through a single switch to select either water or AFFF. The system is switch selectable from 1 to 3 percent.

C. MEASURES OF MERIT

1. The Hypro installed metering system shall meet all of the specifications listed in the statement of work and detailed under Objective 1, Appendix A.

2. The P-19, equipped with the modified metering system and 1 percent AFFF, shall extinguish a fully developed 100-foot JP-4 fuel fire within two minutes from the start of foam application. The fire will be permitted to burn a minimum of 30 seconds before beginning foam application. A 100 percent extinguishment is required.

D. SCOPE

This project evaluated the performance of a precision metering system for the P-19 firefighting vehicle. This system was designed, manufactured, installed, and test assistance provided by the Hypro Corporation. This system replaces the around-the-pump inductor foam-metering system, originally installed in the P-19, with a modern closed-loop computer-controlled system capable of metering either 1 or 3 percent Aqueous Film-Forming Foam (AFFF) with an accuracy on the order of $\pm$10 percent of the specified value (between 0.9 and 1.1 percent for 1 percent AFFF). This test series evaluated the accuracy and reliability of this system in the P-19 vehicle.

This test series culminated with 3 large-scale (8,000 ft^2) fires at the 100 foot diameter Fire Research Facility 1, located at Tyndall AFB, Florida to demonstrate the effectiveness of 1 percent AFFF, when accurately metered by the P-19, in extinguishing large hydrocarbon fires.

E. AUTHORITY

HQ USAF Program Management Directive (PMD) Number 63723F (2104), dated March 1985, provided the authority for this test. This test program was conducted in accordance with the PMD and AFR 80-14.

SECTION II

TEST DESCRIPTION

A. INTRODUCTION

This test program was conducted in three parts, the P-19 firefighting vehicle metering tests, the foamability tests, and the Large-Scale AFFF fire tests. The AFFF foamability tests were added to those listed in the test plan to demonstrate that the foam quality, with the modified metering system, was not degraded, as compared to that of the original metering system. Each test series is described in the following paragraphs. This test series was conducted at the AFESC Fire test facility at Sky X and the AFESC Fire Research Facility 1, located at Tyndall AFB, Florida, approximately 7 miles southeast of the main gate and approximately 1.5 miles east of U.S. Highway 98 on Farmdale Road. Tyndall AFB is located on the Gulf Coast of Florida, about 10 miles southeast of Panama City, on US Highway 98.

B. P-19 FIREFIGHTING VEHICLE METERING TESTS

The objective of this test series was to demonstrate that the P-19, modified with the precision AFFF metering system, will dispense foam at 1 and 3 percent and meet all specifications contained under Objective 1. The Hardened P-19 firefighting vehicle, used in the P-19 Hardened Vehicle Program at Oak Ridge National Laboratory, Oak Ridge, Tennessee, was used for this program.

The P-19 was calibrated and tested to determine its capability to meter and dispense an AFFF/water mixture in ratios of 1 and 3 percent AFFF to 99 and 97 percent water, respectively. To determine the metering system performance and specification compliance the following procedures were completed:

1. Site-glasses showing the fluid levels of the water and AFFF tanks, one for each tank, were installed on the side of the vehicle. The tanks were emptied and cleaned. Each tank was filled in increments (50 gallon increments for the water tank and 5 gallon increments for the AFFF tank) using a precision flow meter. The depth of each tank, in inches on the site glasses, was recorded at each incremental level. These data were entered into a portable computer as a look-up table. By using the look-up table and linear interpolation, the computer calculated the tank levels in gallons. By entering the dispensing time and tank levels in inches both before and after each foam dispensing operation the computer program calculated the quantities used, mixture ratio, and flow rate for each test run.

2. The metering system modification and installation were inspected to determine that the system fit totally within the compartment(s) of the P-19, that no part of the system protruded outside of the vehicle, and that the system utilized the existing water and AFFF tanks, plumbing and pump.

3. All components comprising the system modification were inspected to determine that they were constructed of noncorrosive materials (stainless steel, brass, plastic, or other non-corrosive material) so as not to degrade while operating in direct contact with AFFF and water.

4. The operation of the system and operator interface was evaluated to determine that the mixing ratio was adjustable over a range of 1 to 3 percent and that this adjustment is made only at the control unit itself, located in a small compartment just aft of the left front wheel, and not at the operator's console. The operators console in the vehicle cab was inspected to determine that the on/off switch operated and was labeled, "WATER ONLY" in the off position and "AFFF" in the on position and that it also contained a resettable totalizer for water and AFFF quantities used, in accordance with the Statement of Work.

5. To verify that the metering system met the metering accuracy specification over the range of possible flow rates for the vehicle the following procedures were followed: After the AFFF and water tanks were calibrated as described in paragraph 1, the tanks were filled and the vehicle leveled near the 100-foot fire pit. To conserve the on-hand supply of AFFF, initial tests were conducted using water in both the water and AFFF tanks. Foam, or water if the AFFF tank has been filled with water, was dispensed in intervals from 60 to 180 seconds. The actual dispensing time and tank levels were recorded before and after each run. After entering these data into a portable computer, the computer calculated the fluid quantities used, dispensing ratio, and flow rates. After several practice and calibration runs were accomplished, a 12-run test matrix was completed for 1 percent and 3 percent AFFF. The test matrices, with test results, are contained in Tables 1 and 2 in Section III, Test Results.

C. FOAMABILITY TESTS - (IAW NFPA STANDARD 412)

These tests were conducted on the foam dispensed from the bumper turret to evaluate the foam quality of the modified metering system. The bumper turret was selected as the foam source as this turret has a lower flow rate than the roof turret while maintaining the correct ratio. The handline was not used for this test as it dispenses a richer mixture foam due to the limits of the AFFF metering pump. The minimum flow rate of the AFFF metering pump results in an actual mixture ratio approximately 1 percent higher than the specified value (2 percent when 1 percent is selected). Foam was dispensed from the bumper turret onto the foam collecting stand in accordance with NFPA Standard 412, Method A. Foam was sprayed on the foam sample collector and collected in two standard 1000 ml graduated cylinders. Once the foam containers were completely filled, foam application was discontinued and the timing of the 25 percent drainage time started, excess foam was struck from the top of the containers with a straight edge and the containers were wiped clean. The total weight of the foam sample was determined to the nearest gram by subtracting the weight of the empty containers from that of the full containers. The weight of the foam in grams was divided by four to obtain the 25 percent drainage volume in milliliters. At 1 minute intervals, the level of accumulated solution in the cylinder was recorded. The drainage time versus the volume relationship was recorded until the 25 percent volume was exceeded. The 25 percent drainage time was interpolated from the data.

CRITERIA: Foam expansion minimum - 3:1
Foam drainage time minimum - 1 minute

REFERENCE: NFPA Standard 412, Test Method A,
Paragraph 3-1.1 & Table 3-1

D. LARGE SCALE FIRE TESTS

The objective of this test series was to observe the firefighting performance of 1 percent AFFF as compared with the Air Force standard 3 percent AFFF in combating large JP-4 pool fires. Similar data were obtained in 1979 and 1980 for the 3 and 6 percent concentrates. Extinguishing times for the 1 percent AFFF were compared with those from the 3 percent foam.

This test series consisted of three 100-foot JP-4 pool fires (one using 3 percent AFFF and two using 1 percent AFFF). Fires were conducted at the 100 foot diameter (8,000 ft^2) AFESC Fire Research Facility 1. The modified P-19 was the primary fire-extinguishing vehicle with a P-4 used as the backup vehicle.

SECTION III

TEST RESULTS

A. GENERAL

This test program was conducted in three parts as described in Section II, Test Description. The results of each test series are presented in the following paragraphs.

B. P-19 FIRE-FIGHTING VEHICLE METERING TESTS

After selecting the Hypro Corporation to design, manufacturer, and install the system, a detailed system design was presented by Hypro. The design was accepted with minor modifications and Hypro was given the go-ahead to construct the system. The P-19 firefighting vehicle was modified with the new metering system by Hypro personnel, with assistance and overview by AFESC/RDCF personnel. When installation was completed and initial shakedown tests were completed, the system was inspected and tested to determine compliance with the Statement of Work. Metering accuracy test results are contained in Tables 1 and 2, with averages presented in Table 3. Following are the results of those inspections, paragraph by paragraph in accordance with the SOW and repeated under Objective 1:

1. The system was inspected and found to fit within the P-19 compartments with no part of the system protruding outside of the vehicle. The system utilizes the existing water and AFFF tanks, plumbing and water pump. The installation is a neat, professionally completed job. The system is designed and installed so that the vehicle may be easily restored to its original metering system configuration.

2. All system components were inspected and found to be constructed of industrial grade, noncorrosive materials (brass or stainless steel). No corrosion has been found on the system to date, over 6 months after initial installation.

3. The dispensing ratio is adjustable at the control unit mounted in the small equipment storage compartment just behind the left front wheel over a range of 1.0 percent to 3.0 percent. A small panel must be removed and a 10-position switch adjusted, using a small common screwdriver. The entire operation requires about 1 minute to complete. As specified, the dispensing ratio is not adjustable at the operator's console within the vehicle cab. The manufacturer indicated that a change could be easily included to provide this option, if desired, at a later date.

4. The operator's console in the vehicle cab includes an on/off switch labeled, "WATER ONLY" in the off position and "AFFF" in the on position. This is the only switch that the operator need be concerned with in the operation of the system. The operator's console contains a resettable totalizer for water and AFFF quantities used.

TABLE 1. P-19 AFFF PRECISION METERING TEST MATRIX AND RESULTS - 1 PERCENT TEST RUNS

TEST NO.	TURRET	AFFF TANK	PLANNED DISPENSING TIME (sec)	ACTUAL DISPENSING TIME (sec)	WATER TANK INCHES START	WATER TANK INCHES END	WATER TANK GALLONS START	WATER TANK GALLONS END	AFFF TANK INCHES START	AFFF TANK INCHES END	AFFF TANK GALLONS START	AFFF TANK GALLONS END	WATER USED	AFFF USED	CALC. RATIO %	TARGET RATIO %	FLOW RATE (GPM)	AMB. TEMP	TEST DATE
1	ROOF	WATER	90	90.42	45.937	23.625	992.59	340.00	38.687	37.625	115.50	108.64	652.59	6.8636	1.0517	1	437.59	81	10/05
2	ROOF	AFFF	90	91.7	46	23.562	994.44	338.33	28.125	27.125	41.82	35.00	656.11	6.8181	1.0391	1	433.75	83	10/05
3	BUMPER	WATER	90	90	44.687	32.312	955.56	584.48	37.25	36.75	105.91	102.50	371.07	3.4090	0.9187	1	249.65	81	10/05
4	BUMPER	WATER	90	90.57	32.312	18.25	584.48	218.92	36.75	36.187	102.50	98.50	365.56	4	1.0942	1	244.82	81	10/05
5	HANDLINE	WATER	180	181	19.437	10.25	244.59	50.00	39.187	38.562	119.50	114.62	194.59	4.8846	2.5101	1	66.125	76	10/04
6	HANDLINE	WATER	120	121.69	23.625	17.812	340.00	209.46	37.625	37.187	108.64	105.45	130.54	3.1818	2.4374	1	65.932	81	10/05
7	HANDLINE	AFFF	120	180.87	23.562	14.937	338.33	148.68	27.125	26.562	35.00	30.91	189.64	4.0909	2.1570	1	64.269	83	10/05
8	ROOF/BUMP	WATER	60	61.21	44.125	19.875	938.89	253.85	36.187	35.187	98.50	91.25	685.04	7.25	1.0583	1	678.60	81	10/05
9	ROOF/BUMP	WATER	60	60.17	45.25	21.562	972.22	288.46	35.187	34.25	91.25	84.58	683.76	6.6666	0.975	1	688.47	81	10/05
10	ROOF/BUMP	AFFF	60	60.68	43.125	18.437	909.26	222.97	25.687	24.375	25.00	16.79	686.28	8.2142	1.1969	1	686.71	85	10/05

NOTE: 3M 1 percent AFFF, CODE FC-201 USED FOR AFFF TESTS.

TABLE 2. P-19 AFFF PRECISION METERING TEST MATRIX AND RESULTS - 3 PERCENT TEST RUNS

TEST NO.	TURRET	AFFF TANK	PLANNED DISPENSING TIME (sec)	ACTUAL DISPENSING TIME (sec)	WATER TANK INCHES START	WATER TANK INCHES END	WATER TANK GALLONS START	WATER TANK GALLONS END	AFFF TANK INCHES START	AFFF TANK INCHES END	AFFF TANK GALLONS START	AFFF TANK GALLONS END	WATER USED	AFFF USED	CALC. RATIO %	TARGET RATIO %	FLOW RATE (GPM)	AMB. TEMP	TEST DATE
1	ROOF	WATER	90	90.58	45.812	23.875	988.89	346.67	35.562	32.75	93.75	74.17	642.22	19.583	3.0493	3	438.37	90	10/04
2	ROOF	WATER	90	90.96	45.875	24.062	990.74	351.67	40.312	37.5	128.33	107.73	639.07	20.606	3.2243	3	435.14	84	10/04
3	ROOF	AFFF	60	90.8	46.062	24.125	996.30	353.33	37.75	35.187	109.55	91.25	642.96	18.295	2.8454	3	436.95	89	10/05
4	BUMPER	WATER	90	90.66	43.25	30.875	912.96	544.64	36.875	35.375	103.33	92.50	368.32	10.833	2.9412	3	250.92	76	10/04
5	BUMPER	WATER	90	90.19	30.875	16.437	544.64	180.26	35.375	33.75	92.50	81.25	364.37	11.25	3.0874	3	249.89	89	10/05
6	BUMPER	AFFF	90	91.25	36.28	23.812	704.43	345.00	34.812	33.5	88.64	79.55	359.42	9.0909	2.5292	3	242.31	89	10/05
7	HANDLINE	WATER	180	180.01	23.875	15.437	346.67	159.21	32.75	31.687	74.17	66.50	187.45	7.6666	4.0898	3	65.037	90	10/04
8	HANDLINE	WATER	120	122.8	24.062	18.562	351.67	225.68	37.5	36.75	107.73	102.50	125.99	5.2272	4.1489	3	64.113	86	10/04
9	HANDLINE	AFFF	120	120.64	24.125	18.875	353.33	232.43	35.187	34.562	91.25	86.82	120.90	4.4318	3.6656	3	62.333	89	10/05
10	ROOF/BUMP	WATER	60	60.43	41.375	17.375	857.41	200.00	33.625	30.75	80.42	59.55	657.40	20.871	3.1747	3	673.45	76	10/04
11	ROOF/BUMP	WATER	60	60.32	44	20.25	935.19	261.54	30.812	27.937	60.00	40.45	673.64	19.545	2.9014	3	689.51	76	10/04
12	ROOF/BUMP	AFFF	30	60.56	42.5	18.375	890.74	221.62	33.5	30.875	79.55	60.45	669.11	19.090	2.8531	3	681.84	89	10/05

NOTE: Ansul 3 percent AFFF, BATCH # X26011 4/86 used for AFFF TESTS.

5. Metering System Accuracy Tests. The system was required to maintain a metering ratio of AFFF to water at its preset value (over a range of 1 - 3 percent) within a tolerance of ±10 percent (i.e., between .9 and 1.1 percent when set for 1 percent metering and between 2.7 and 3.3 percent when set for 3 percent metering) for flow rates between 300 and 840 Gallons per minute (gpm). Between 60 and 300 gpm the system was permitted a reduced metering accuracy of -10 percent and +100 percent (ie. between .9 percent and 2 percent when set for a 1 percent metering ratio and between 2.7 percent and 6 percent when set for a 3 percent metering ratio).

After several practice and calibration runs were completed to adjust the system, matrices of record runs were made, using the various combinations of nozzles and systems on the P-19. These matrices, complete with test results are contained as Tables 1 and 2. Since the handline was permitted to operate over a wider tolerance on the rich side, data for the handline are considered separately from those of the roof and bumper turrets. Average metering ratios are shown in Table 3. The average metering ratios at 1 and 3 percent for the roof and bumper turrets were within the ±10 percent limit (10 percent of the selected ratio). The handline at 1 percent was higher than the 2.0 percent specified limit. However, since handline use is a very small percentage of total AFFF use, this is not considered significant.

The overall metering accuracy is significantly better than the standard P-19 around-the-pump metering system and is considered excellent. Throughout the test program the system reliability was excellent with no component failures. The hydraulic system required three filter changes during the test period to remove some contaminants. These particles had apparently been inadvertently introduced during the manufacture of the replacement hydraulic tank. The manufacturer has been advised. Standard clean assembly procedures for hydraulic components during a production operation should remedy this problem.

Table 3. AVERAGE METERING RATIOS

TARGET RATIO	ALL ROOF & BUMPER RUNS	BUMPER ONLY	ROOF ONLY	SIMULTANEOUS ROOF & BUMPER TURRETS	HANDLINE ONLY
1 %	1.05	1.01	1.05	1.08	2.37
3 %	2.96	2.85	3.04	2.98	3.97

C. FOAMABILITY TESTS - (IAW NFPA STANDARD 412)

To evaluate the quality of the foam produced by the modified metering system, foamability tests were conducted in accordance with NFPA Standard 412 for the 1 and 3 percent agents on hand. These included 3 percent agents from 3M and ANSUL and 1 percent agents from 3M, ANSUL, and National Foam. In accordance with NFPA 412, the criteria for minimum expansion ratio and 25 percent drainage time for a nonaspirated nozzle are 3:1 and 1 minute, respec-

tively. All expansion ratios were well above the 3:1 minimum, ranging from 5.3 to 13.1. Average drainage times were 2 minutes for the 1 percent agents and 2 minutes and 17 seconds for the 3 percent agents. All agents evaluated passed this test. Test results, including averages of the 25 percent drainage times and expansions ratios for 1 and 3 percent foams, are contained in Table 4.

Table 4. P-19 FOAMABILITY TEST RESULTS

CRITERIA: Foam expansion - 3:1 minimum
Foam drainage 25 percent - 1.0 minutes minimum

REF: NFPA 412, Test Method A, Paragraph 3-1.1 & Table 3-1

DATE	MANF.	FINAL CONTAINER WEIGHT	25% DRAINAGE WEIGHT	SOLUTION VOLUME (ml) IN MINUTES 1	2	3	4	25% DRAINAGE TIME MIN:SEC	EXPANSION RATIO
21 NOV 90	3M 3%	461.6	47.2	38	45	62	79	2:08	5.3:1
21 NOV 90	3M 3%	454.9	45.5	35	41	59	76	2:15	5.5:1
21 NOV 90	3M 3%	413.1	35.1	26	30	37	49	2:44	7.1:1
21 NOV 90	3M 3%	398.3	31.4	24	27	33	42	2:44	8.0:1
21 NOV 90	ANSUL 3%	406.4	33.4	29	32	47	58	2:06	7.5:1
21 NOV 90	ANSUL 3%	419.8	36.8	30	35	49	61	2:08	6.8:1
21 NOV 90	ANSUL 3%	457.7	46.2	37	43	61	79	2:11	5.4:1
21 NOV 90	ANSUL 3%	457.3	46.1	39	45	63	79	2:04	5.4:1
26 NOV 90	3M 1%	363.6	22.7	20	25	28	33	1:32	11.0:1
26 NOV 90	3M 1%	365.2	23.1	20	25	28	33	1:37	10.8:1
26 NOV 90	3M 1%	349.0	19.0	19	22	27	32	1:00	13.1:1
26 NOV 90	3M 1%	362.0	22.3	25	27	33	44	0:55	11.2:1
27 NOV 90	NF 1%	410.1	34.3	25	34	47	60	2:02	7.3:1
27 NOV 90	NF 1%	421.0	37.1	29	41	53	68	1:40	6.7:1
27 NOV 90	NF 1%	382.2	27.3	20	23	27	36	3:02	9.1:1
27 NOV 90	NF 1%	397.0	31.0	20	23	30	40	3:06	8.1:1
27 NOV 90	ANSUL 1%	389.9	29.3	25	30	40	50	1:51	8.5:1
27 NOV 90	ANSUL 1%	386.8	28.5	25	28	34	46	2:05	8.8:1
27 NOV 90	ANSUL 1%	378.4	26.4	20	25	28	39	2:28	9.5:1
27 NOV 90	ANSUL 1%	379.2	26.6	20	25	28	38	2:32	9.4:1
						Averages 1% -		2:00	9.5:1
						Averages 3% -		2:17	6.4:1

D. LARGE SCALE FIRE TESTS

Three large-scale (100-foot diameter) fire tests were conducted on 29 May 1991 to evaluate the firefighting effectiveness of 1 percent AFFF and compare the results with those of 3 percent AFFF. Each fire burned 500 gallons of JP-4 jet fuel floating on water in the 100-foot fire test facility. The first fire test was completed, using 3 percent AFFF to extinguish the fire. Two fires used 1 percent AFFF to extinguish the fire. The AFFF metering system was set to the appropriate setting for the 3 and 1 percent agents. Table 5 in-

cludes the fire suppression times and agent quantities (water and agent combined) used. The modified P-19 firefighting vehicle was used to extinguish all fires. The first fire, using 3 percent AFFF, was extinguished in 1 minute and 12 seconds. The two fires using 1 percent AFFF were extinguished in 22 seconds and 43 seconds, respectively.

Firefighter personnel conducting the test subjectively evaluated the foam quality from both agents and judged the foam from the 1 percent agent superior to that of the 3 percent agent. The three test fires conducted do not constitute a database of sufficient size to state that 1 percent AFFF is superior to 3 percent agent, however, test results do indicate that 1 percent AFFF is at least comparable to 3 percent AFFF in fire suppression performance.

Table 5. LARGE-SCALE FIRE SUPPRESSION PERFORMANCE

TEST NUMBER	TEST DATE	AGENT TYPE	QTY. USED	EXTINGUISH TIME (sec)
1	29/05/91	3M 3%	535 gal	1:12 min.
2	29/05/91	3M 1%	200 gal.	0:22 min.
3	29/05/91	3M 1%	390 gal.	0:43 min.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The prototype unit manufactured and installed by Hypro Corporation was well designed and professionally installed. This is a well engineered system that meets all of the objectives contained in the Statement of Work. Metering accuracy is excellent. The primary nozzles of the P-19, roof and bumper turrets, maintain metering at either 1 or 3 percent within the specified tolerance of $\pm$0.1 percent for 1 percent and $\pm$0.3 percent for 3 percent. The handline meters at approximately 1 percent higher than the selected ratio (2 percent when 1 percent is selected). This is a designed-in variance to permit the system to operate accurately within a wide range of flow rates while eliminating the requirement for a two-pump system. This has no operational impact, as the handline has a much lower flow rate and the error is always on the rich side, guaranteeing satisfactory foam at all times.

Foam quality was checked, using NFPA Standard 412 procedures, and found to be well within those criteria. The system has been operating for over 6 months with no component failures. Throughout the test program the system reliability was excellent. The hydraulic system required three filter changes during the test period to remove some contaminates. These particles had apparently been inadvertently introduced during the manufacture of the replacement hydraulic tank. Production standard clean assembly procedures for hydraulic components should remedy this problem for a production system. Initial cost estimates are approximately $8,000/unit for a P-19 fleet retrofit.

One percent AFFF was found to be at least as effective and possibly more effective, than 3 percent AFFF in extinguishing large JP-4 fires.

B. RECOMMENDATIONS

1. The USAF Chief of Fire Protection (AFESC/DEMF) should consider adapting precision metering system technology to:

   a. Retrofit the P-19 fleet.

   b. Modify new production line P-23 vehicles or retrofit vehicles in the field.

   A performance Specification for P-19 and P-23 metering system retrofit has been prepared by AFESC/RDCF.

2. The USAF Chief of Fire Protection (AFESC/DEMF) should consider the use of 1 percent AFFF versus 3 percent foam when precision metering systems are operational on CFR vehicles.

APPENDIX A

P-19 PRECISION METERING
AND ONE PERCENT AFFF
LARGE-SCALE FIRE PERFORMANCE
TEST PLAN

AIR FORCE ENGINEERING AND SERVICES CENTER
Tyndall Air Force Base, Florida 32403

P-19 PRECISION METERING

AND ONE PERCENT AFFF

LARGE-SCALE FIRE PERFORMANCE TEST

AUGUST 1990

TEST PLAN

This test plan has been reviewed and approved by:

JOSEPH L. WALKER
Chief, Airbase Fire Protection
and Crash Rescue Systems Branch

ALVAH R. PARSONS
USAFADWC/SEG (GROUND SAFETY)

RICHARD REID, Captain, USAF
AFESC/RDCS
Safety Officer

RICHARD M. HANES, Colonel, USAF
Director, Engineering and
Services Laboratory

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SECTION I

INTRODUCTION

A. SCOPE

This project will evaluate the performance of a precision metering system for the P-19 firefighting vehicle. This system will be designed, manufactured, installed, and test assistance provided by the Hypro Corporation. This system will replace the around-the-pump eductor foam metering system, originally installed in the P-19, with a modern closed-loop computer-controlled system that is capable of metering either 1 or 3 percent Aqueous Film-Forming Foam (AFFF) with an accuracy on the order of ±10 percent of the specified value (between 0.9 and 1.1 percent for 1 percent AFFF). This test series will evaluate the accuracy and reliability of this system in the P-19 vehicle.

This test series will culminate with six large-scale (8,000 ft^2) fires at the 100-foot diameter Fire Research Facility 1, located at Tyndall AFB, Florida to demonstrate the effectiveness of 1 percent AFFF, when accurately metered by the P-19, in extinguishing large hydrocarbon fires.

B. BACKGROUND

The Department of Defense uses AFFF concentrates formulated to be mixed with water in ratios of 3 and 6 percent. Common terminology in the fire protection community refers to an AFFF concentrate designed to be mixed with water at a ratio of 3 percent AFFF to 97 percent water as "3 percent AFFF." A "6 percent AFFF" concentrate contains approximately one-half of the surfactant and other active ingredients as 3 percent AFFF concentrate per unit volume and consequently is referred to as, "less concentrated". When mixed with water at its designed ratio, either type AFFF/water mixture is essentially the same. By using an even more concentrated AFFF concentrate (1 percent as compared to 3 and 6 percent), mixed 1 percent with water, a considerable costs savings in the shipping and storage of the smaller agent quantities required will be realized. An operational capability increase will also be realized since the firefighting vehicle will require less frequent refilling of the AFFF tank.

The Air Force's frontline firefighting vehicle, the P-19, is configured to dispense AFFF at a 3 percent AFFF/water ratio. During tests conducted by AFESC during 1988-89 using a typical P-19, the mixing ratio varied from 3.0 to 5.9 percent. Attempts to meter at 1 percent by replacing the orifice plate with a plate with smaller metering holes was unsuccessful.

If the Air Force is to fully realize the benefit of using 1 percent AFFF, the P-19, as well as other Air Force firefighting vehicles, must be capable of accurately metering AFFF at the prescribed 1 percent ratio, within a 10 percent tolerance. With the current commercial availability of 1 percent AFFF the Air Force must have the capability to use this agent, with its inherent cost savings and increased firefighting longevity due to its more concentrated form. This new precision metering system will provide accurate AFFF metering with the same operator interface as the original system in the P-19.

C. AUTHORITY

HQ USAF Program Management Directive (PMD) Number 63723F (2104), dated March 1985, provides the authority for this test. This test program will be conducted as directed in the PMD and AFR 80-14.

D. PURPOSE

The purpose of this test is to demonstrate the performance and accuracy of the Hypro modified P-19 AFFF metering system. The secondary purpose is to demonstrate the effectiveness of 1 percent AFFF, when accurately metered by the modified P-19, in extinguishing large-scale (100-foot diameter) JP-4 fuel fires.

SECTION II

TEST OBJECTIVES AND TESTING MEASURES OF MERIT

A. TEST OBJECTIVES

The overall objective of this test series is to verify the accuracy of the Hypro modified AFFF metering system in the P-19 firefighting vehicle. The secondary objective is to demonstrate the effectiveness of 1 percent AFFF in extinguishing large hydrocarbon fires.

Specific objectives are as follows:

1. Objective 1: Verify that the Hypro-installed precision metering system meets or exceeds the specifications listed in the statement of work and repeated below:

- o The system shall fit totally within the compartment(s) of the P-19; no part of the system may protrude outside of the vehicle and will utilize the existing water and AFFF tanks, plumbing and pump.

- o The total system and all components comprising the system shall be constructed of noncorrosive materials and suffer no degradation while operating in direct contact with AFFF and seawater in an environment of -40°F to 120°F and humidity of 100 percent.

- o The dispensing ratio shall be adjustable at the unit only (not at the operator's console within the vehicle cab) over a range of 1.0 percent to 3.0 percent.

- o The system shall maintain the metering ratio of AFFF to water at its preset value (over a range of 1 - 3 percent) within a tolerance of .1 percent (ie between .9 and 1.1 percent when set for 1 percent metering) for flow rates between 300 and 840 Gallons per minute (gpm). Between 60 and 300 gpm the system will be permitted a reduced metering accuracy of - 0.1 percent and +1.0 percent (ie. between .9 percent and 2 percent when set for a 1 percent metering ratio), if required to maintain an economical system design. The reduced metering accuracy at the low flow rates of the hand line pose little or no operational impact to the Air Force as relatively small agent quantities are used by the handline and the ratio error is on the rich side, ensuring an adequate fire extinguishing agent. The reduced accuracy is allowed to permit the use of a single AFFF pump instead of dual pumps (one large and one small pump), thereby reducing system cost.

- o The operators console in the vehicle cab shall include an on/off switch labeled, "WATER ONLY" in the off position and "AFFF" in the on position. The operators console shall also contain a resetable totalizer for water and AFFF quantities on board. These totalizer displays may display calculated quantities based upon knowing the total fluid quantities and subtracting the integrated flow rates to obtain the current quantities on-board. An actual quantity measuring device need not be installed in the water and AFFF tanks.

- o Industrial grade components are acceptable in this prototype system.

- o The system will be designed and installed so that the vehicle may be easily restored to its original metering system configuration.

2. Objective 2: Demonstrate the effectiveness of 1 percent AFFF in extinguishing large hydrocarbon pool fires by conducting 6 large-scale (8,000 ft^2) JP-4 pool fire tests. Six large-scale fires will be conducted to allow some measure of repeatability in the fire extinguishing capability of the agent. Previous large-scale fire test series have used six fires and have been shown to be a reasonable compromise between a large statistically data sample and a cost-effective test series.

B. MEASURES OF MERIT

1. The Hypro-installed metering system shall meet all of the specifications listed in the statement of work and detailed under Objective 1.

2. The P-19, equipped with the modified metering system and 1 percent AFFF shall extinguish a fully-developed 100-foot JP-4 fuel fire within 2 minutes from the start of foam application. The fire will be permitted to burn a minimum of 30 seconds before beginning foam application. A 100 percent extinguishing rate is required.

SECTION III

MANAGEMENT AND ORGANIZATIONAL RESPONSIBILITIES

A. MANAGEMENT

Overall test responsibility rests with the AFESC/RDCF Test Director. The Test Director will delegate authority, as necessary. Specific responsibilities for safety, security, communication, photography, and engineering support are contained in the test plan annexes.

B. ORGANIZATIONAL RESPONSIBILITIES

1. HQ AFESC

The Air Force Engineering and Services Center is responsible for overall test management.

2. AFESC/RDCF

RDCF will:

a. Develop, coordinate, and publish a test plan.

b. Provide the test director.

c. Prepare a test report, detailing the test preparation and method of test.

3. AFESC/WE (Staff Meteorologist):

WE will:

During the large-scale fires, provide daily weather forecasts and briefings to the test director. If the AFESC Staff Meteorologist is unavailable, weather briefings will be provided by the Tyndall Base Weather Station.

4. AFESC/PA (Public Affairs Office)

PA will:

Be responsible for notification and media inquiry response of the test, when applicable.

5. Hypro Corporation:

Hypro Corporation will:

Install and calibrate the precision metering system, that they previously designed and fabricated, in a government-supplied P-19.

Provide test assistance during the metering system test, as required. One design engineer and technician will be on site.

SECTION IV

TEST EXECUTION

A. INTRODUCTION

This test program is divided into two parts, the P-19 firefighting vehicle metering tests and the Large-scale fire tests. Each test series is described in the following paragraphs.

B. TEST SITE

This test series will be conducted at the AFESC Fire Research Facility 1, located at Tyndall AFB, Florida, approximately 7 miles southeast of the main gate and approximately 1.5 miles east of U.S. Highway 98 on Farmdale Road. Tyndall AFB is located on the Gulf Coast of Florida, about 10 miles southeast of Panama City, on US Highway 98.

The local soil is characteristic of the coastal lowlands of Western Florida, where fine gray/white beach sands are underlaid at variable depths by the Atronelle Formation. This material is very permeable and free-draining. The subgrade is a poorly graded sand.

The water table in the area varies with the season and may be anywhere from 4 feet to just below the ground surface and usually occurs about 2.5 feet below the surface. Surface drainage is normally in a southerly direction into a swampy area. The only surface water in the immediate area is from one large borrow pit resulting from construction, and seasonal surface water in the swampy area southeast of the test site.

C. TEST SCHEDULE

The test period is planned for 3 weeks beginning 10 September 1990. The P-19 metering system modifications are anticipated to require approximately 1 week with the systems tests the following week and the fire tests during the third week. Calibration of the test P-19 agent and water tanks will be accomplished before the test start date. A more detailed test schedule is contained in Annex 1.

D. SUPPORT REQUIREMENTS

AFESC/RDCF will plan, coordinate and execute the test. A total of 3,000 gallons of JP-4 are required for this test series. AFESC Fire Research Facility 1, to include the fire ignition system, will be the test site for large-scale fires. The modified P-19 and a back-up P-4 firefighting vehicles, supplied by AFESC, are required for the test. Video and still photography of each fire test will be provided by AFESC/RDCF. Detailed support requirements are contained in Annex 2.

E. DATA COLLECTION

1. General

Prior to testing each day, all project participants will be briefed by the test director on data collection and recording requirements. The test director, or his designated representative, will complete the test readiness/ data collection checklist, contained in Annex 6, as testing progresses and ensure that all necessary data and photographs are collected/taken.

2. Video Recording

Video recordings of all testing segments will be made. The video cameras will be configured to record real time on the video tape to facilitate data reduction.

3. Meteorological Data

Meteorological data from the Tyndall Base Weather Station will be recorded for each test day by AFESC/WE and forwarded to the AFESC/RDCF Test Director on a daily basis.

F. P-19 FIRE-FIGHTING VEHICLE METERING TESTS

The objective of this test series is to demonstrate that the P-19, modified with the precision AFFF metering system by the Hypro Corporation, will dispense foam at 1 percent and 3 percent and meet all specifications contained under Objective 1. The Hardened P-19 firefighting vehicle, used in the P-19 Hardened Vehicle Program at Oak Ridge, Tennessee, will be used for this program and is scheduled to be available at Tyndall AFB, Florida by 20 August 1990.

The P-19 fire-fighting vehicle will be calibrated and tested to determine its capability to meter and dispense an AFFF/water mixture in ratios of 1 and 3 percent AFFF to 99 and 97 percent water, respectively. This test series will be accomplished at the AFESC Fire Research Facility 1, located on Farmdale Road. To determine the metering system performance and specification compliance proceed as follows:

1. Calibrate the AFFF and water tanks of the vehicle in accordance with the procedures contained in Annex 4, Firefighting Vehicle Fluid Calibration Procedures.

2. Inspect the metering system modification and installation to determine that the system fits totally within the compartment(s) of the P-19 and that no part of the system protrudes outside of the vehicle. The new system shall utilize the existing water and AFFF tanks, plumbing and pump.

3. Inspect all components comprising the system modification to determine that they are constructed of noncorrosive materials (stainless steel, brass, plastic, or other noncorrosive material) so as not to degrade while operating in direct contact with AFFF and water. A visual inspection will be accomplished during the installation. Industrial grade components are acceptable in this prototype system. This is a reiteration of the SOW.

4. Evaluate the operation of the system and operator interface to determine that the mixing ratio is adjustable over a range of 1 to 3 percent and that this adjustment is made only at the unit itself and not at the operator's console. The operators console in the vehicle cab shall include an on/off switch labeled, "WATER ONLY" in the off position and "AFFF" in the on position. The operator's console shall also contain a resetable totalizer for water and AFFF quantities used.

5. To verify that the metering system meets this metering accuracy specification over the range of possible flow rates for the vehicle proceed as follows: After the AFFF and water tanks of the vehicle have been calibrated as described in paragraph 1 above, fill the tanks and level the vehicle near the 100-foot fire pit. In order to conserve the on-hand supply of AFFF, initial tests will be conducted using water in both the water and AFFF tanks. Dispense foam or water if the AFFF tank has been filled with water, in accordance with the test configurations contained in Annex 5. Record the water and AFFF tank levels before and after the dispensing operation on the data sheets provided. Calculate the metering ratios from the amount of AFFF and water used for each individual test.

The modified AFFF metering system shall maintain the metering ratio of AFFF to water at its preset value (over a range of 1 - 3 percent) within a tolerance of .1 percent (ie between .9 and 1.1 percent when set for 1 percent metering) for flow rates between 300 and 840 Gallons per minute (gpm). Between 60 and 300 gpm the system will be permitted a reduced metering accuracy of -0.1 percent and +1 percent (ie. between .9 percent and 2 percent when set for a 1 percent metering ratio). This richer mixture is permitted at the lower flow rates (when using the handline) to allow the use of a single AFFF metering pump, thereby maintaining an economical design.

G. LARGE SCALE FIRE TESTS

The objective of this test series is to observe the firefighting performance of 1 percent AFFF as compared with the Air Force standard 3 percent AFFF in combating large JP-4 pool fires. Similar data were obtained in 1979 and 1980 for the 3 and 6 percent concentrates. Extinguishing times for the 1 percent AFFF will be compared with those from the 3 percent foam.

This test will include a series of six 100-foot JP-4 pool fires (2 using 3 percent AFFF and 4 using 1 percent AFFF) to be conducted at the 100-foot diameter (8,000 ft^2) AFESC Fire Research Facility 1. The modified P-19 will be the primary vehicle with a P-4 used as the backup vehicle.

1. Test Procedure - General

A total of 6 individual fires are planned for this series. To maintain the flame column in a relatively vertical position, tests will not be run when the low level wind speed exceeds 6 knots. This wind restriction dictates that individual fire tests be conducted during the early morning hours, and possibly during the late afternoon hours. Initial plans are to conduct one test per day during the morning. A second fire will also be conducted during the early evening hours, weather and other scheduling restrictions permitting. Pretest briefings will be conducted the day before each scheduled test, to evaluate weather forecasts, discuss the results of the

previous test, verify that all systems are functional, and plan the next day's mission(s). All personnel will be at their assigned locations a minimum of 2 hours before each scheduled ignition time. All test materials and equipment will be set up and ready for the test a minimum of 1 hour before the scheduled ignition time. At T-30 minutes (30 minutes before ignition time) a pretest checklist, as contained in Annex 6, will be completed to ascertain the readiness of all functions. These functions will include, but are not limited to, safety, weather, test pit readiness, and data collections readiness. When all functions are ready, the fire will be ignited. The order to ignite the fuel will be given by the AFESC Test Director.

2. Test Procedures - Specific

When the test director confirms that all systems are go he will verbally direct ignition. After ignition allow the fire to burn for 30 seconds, then move the P-19 into position and aggressively extinguish the fire. A P-4 with 3 percent AFFF will be readily available and manned as a backup fire-fighting vehicle. Record the time to extinguish the fire. A detailed Large-scale fire operations test checklist is contained in Annex 6.

SECTION V

SAFETY

A. GENERAL

Safety is an integral part of the test. The test director is responsible for accident prevention. Personnel and equipment safety will take precedence over test execution at all times. Special emphasis will be placed on providing thorough supervision and guidance throughout all test phases. Premission briefings will be conducted daily by the test director detailing the test procedures for the day and emphasizing safety in all test phases.

The AFESC Test Director will function as the safety officer and will monitor all test phases. He will suspend the test any time a safety hazard is observed. Identification of a potential safety hazard will result in test suspension until the hazard can be evaluated and corrected to the satisfaction of all responsible agencies.

Emergency medical personnel will be notified via telephone (ext 911 or 283-2333) before each large-scale test that a controlled JP-4 fuel fire will be conducted at AFESC Fire Research Facility 1, located on Farmdale Road, approximately 1.5 miles east of Highway 98 and 7 miles east of Tyndall AFB, Florida.

B. IDENTIFIED HAZARD

A JP-4 open pit fire, by its very nature, is hazardous. The largest fire planned for this test series will be 100 feet in diameter and will burn for approximately 2 minutes. The approved test pit has been thoroughly examined for safety distance from surrounding objects and found to be well within safe distance limits. A P-19 test firefighting vehicle and a backup P-4 firefighting vehicle will be on hand at the test site during all large-scale fires.

C. SAFETY REPORTING

Accidents, incidents, and serious hazards will be reported in accordance with AFR 127-4 through AFESC/SEG and HQ USAFADWC/SEG. The appointed on-site safety officer is responsible for accident/incident reporting.

The Test Director will ensure that all appropriate safety procedures are followed throughout all testing. Testing will be suspended if an event occurs compromising safety. During the large-scale fire testing, personnel will be located a minimum of 400 feet west of the edge of the fire pit.

Additional safety procedures are contained in Annex 3.

SECTION VI

ENVIRONMENTAL IMPACT

In accordance with AFR 19-2, Air Force Form 813 has been completed and approved. The determination has been made that this test series qualifies for a Categorical Exclusion 2y. As stated in the Form 813, it is anticipated that all evidence of visible smoke will be dispersed within 2 hours. Using the Air Quality Assessment Model (AQAM), initial calculations were made for the levels of particulate matter, hydrocarbons, carbon monoxide, and oxides of nitrogen for the 500-gallon fires, planned for this series. The results are contained in Table 4.

Table 4. AIR EMISSION ESTIMATES FOR LARGE HYDROCARBON FIRES

FIRE SIZE		AIR POLLUTANTS*				
GALLONS JP-4	POUNDS JP-4	POUNDS PM	POUNDS CO	POUNDS HC	POUNDS NOx	TOTAL
500	3,250	420	184	1,048	14	1,666
APPROXIMATE TOTAL FOR TEST SERIES						
3,000	19,650	2,520	1,104	6,288	84	9,996

* PM = Particulate Matter
CO = Carbon Monoxide
HC = Hydrocarbons
NOx = Oxides of Nitrogen

Reference: A Generalized Air Quality Assessment Model for Air Force Operations, AFWL-TR-74-304, February 1975.

Any major fuel spills or other unplanned event that may affect the environment will immediately be reported to the AFESC and Tyndall AFB environmental offices.

ANNEX 1

TEST SCHEDULE

P-19 METERING AND

LARGE-SCALE TEST SERIES

EVENT	WEEK BEGINNING
PRETEST ACTIVITIES:	
CALIBRATE AFFF AND WATER TANKS ON THE TEST P-19	20 AUG 90
INDIVIDUAL TEST ACTIVITIES:	
INSTALL AND INSPECT P-19 PRECISION METERING SYSTEM	10 SEP 90
P-19 METERING TESTS	17 SEP 90
LARGE-SCALE FIRE TEST SERIES	24 SEP 90
DATA REDUCTION AND ANALYSIS	1 OCT 90
DRAFT AFESC TEST REPORT	15 OCT 90

ANNEX 2

LOGISTICS SUPPORT

A. FACILITY REQUIREMENTS

The test facility for this test is the 100-foot AFESC Fire Research Facility 1, located approximately 7 miles southeast of the main gate at Tyndall AFB, Florida. This test site will be used for all fires conducted in this series.

B. PERSONNEL REQUIREMENTS

Personnel to support this test will come from numerous agencies and organizations. Following is a listing of the associated agencies and organizations and the personnel requirements of each:

Agency/Organization	Personnel Required
AFESC/RDCF	Test Director Fire Pit Operator (2 ea) Data collector (3 ea) Video Operator (2 ea)
AFESC/WE	Staff Meteorologist
USAF HOSPITAL - TYNDALL AFB	Emergency Medical Care
HYPRO CORPORATION	Metering System Modification team

C. MATERIAL REQUIREMENTS

Material requirements are as follows:

ITEM	QUANTITY	SOURCE
JP-4	3,000 gal.	AFESC/RDCF
Video tape	24 cassettes	AFESC/RDCF
35 mm film	6 rolls	AFESC/RDCF
AFFF 1%	50 gallons	AFESC/RDCF
AFFF 3%	90 gallons	AFESC/RDCF

D. EQUIPMENT REQUIREMENTS

ITEM	QUANTITY
P-19 Firefighting Vehicle with Hypro AFFF metering system	1
P-4 Firefighting Vehicle	1
Portable Fire Extinguishers	4
Protective Clothing (sets)	3
First Aid Kit	1
Hand Held Radios	2
Electric Ignition System	1
35mm Still Frame Cameras	2
VHS 1/2" Video Cameras	2
Temperature Reading Devices	2
Stopwatches	2
Wind Direction Sock	1

ANNEX 3

SAFETY

A. PURPOSE

This Safety Plan establishes the safety areas for the large scale fire testing of partial percentage Aqueous Film-Forming Foam (AFFF). Fire tests will be conducted at the AFESC Fire Research Facility 1 located on Farm Dale Road, Tyndall AFB, FLorida. This plan identifies the agency responsible for the test area. This document contains detailed Safety Rules which govern the conduct of this test series. The Test Director will act as Supervisor of Fire Test (SOFT) and will insure adherence of all safety policies. Before conducting any live fire tests at the Fire Research Facility, the Base Fire Department Communications Center will be notified. The following documents are applicable to this test:

AFOSH 127-40 & 42, Emergency Eye Wash
AFOSH 127-11 & 50, First Aid Kits
AFOSH 127-31, Personal Protective Clothing and Equipment
AFR 92-1, Paragraph 4-14, Safety Equipment for Fire Fighters
AFR 127-4, Accident Reporting

B. OVERALL SAFETY RESPONSIBILITY

HQ AFESC/RDCF, as Test Director, is responsible for enforcing the overall safety program for the test. The Test Director or his designated representative will act as the Safety Officer during all tests and all other events at the test site. The Test Director will maintain close coordination with the AFESC Safety Officer and the Air Defense Weapons Center Ground Safety Officer on all safety matters.

C. GENERAL SAFETY

1. Safety Briefing. The Test Director will brief all test personnel on known safety hazards in associated with this test and test site. Supervisors will, in turn, brief their personnel on these hazards.

2. Visitors. Visitors will be permitted at the test site only with the approval of the Test Director. Visitors will be instructed on applicable safety regulations.

3. Individual Safety Responsibility. Careful attention to potential hazards associated with fire testing must be stressed at all levels of responsibility. The purpose of the safety rules outlined herein is to present the most important elements in experimenting with controlled fires. These rules do not cover all the possible hazards which may occur at the site. As new problems arise, new safety measures must be established. This Safety Plan must be strictly adhered to by all personnel and enforced by all supervisors. The procedures outlined in the plan shall be accepted as minimum safe conduct. Only the Test Director, with the concurrence of the AFESC Safety Officer, may authorize a deviation from this plan.

4. Vehicles. For vehicles other than fire-fighting vehicles conducting actual fire-fighting operations, speeds shall not exceed 20 mph when driving on unpaved roads. Seat belts will be used at all times while vehicles are in motion. When a vehicle is parked, the hand brake will be set and the transmission put in park or reverse. Unauthorized vehicles will not be parked in the vicinity of the fire pit during fire test operations.

5. First Aid. An adequate supply of first-aid items will be maintained at the site. These items will be properly stored and periodically inspected. All personnel will be briefed upon the locations of first aid kit/supplies.

6. Accident Reporting (Emergency).

a. Scope. The purpose of this procedure is to ensure expedient handling and care of personnel injured in an accident or disaster. All post-emergency reporting and investigation of an accident will be performed in accordance with applicable Air Force Regulations.

b. Responsibility. Each person involved in this program must be familiar with the emergency reporting procedures established by this plan and immediately implement these procedures in the event of an accident. The Test Director will insure that all supervisors and subordinates are familiar with this procedure.

c. Emergency Reporting Procedures. In the event of an accident at the test site, the following procedures will be followed:

(1) The Test Director will direct appropriate first aid. Caution will be exercised to prevent aggravation of an accident-related injury.

(2) Tyndall Air Force Base Hospital Ambulance Service will be notified by calling extension 911. The nature of the accident, including apparent condition of injured personnel and the location of the test site, will be reported to the medical personnel. The Test Director or his designated representative will decide whether to transfer the injured directly to a hospital or to request emergency ambulance support.

(3) The Test Director or his designated representative will deter-mine the seriousness of the accident. If the accident is not serious enough to require emergency hospitalization or ambulance service, the injured person will be taken to a doctor or hospital by normal means of transportation.

(4) All accidents requiring emergency treatment or first aid must be reported to the AFESC Safety Officer.

D. FIRE PREVENTION, REPORTING, AND EMERGENCY PROCEDURES

This paragraph defines the responsibility for fire prevention and reporting procedures related to the test.

1. Responsibility. The Test Director will be responsible for the implementation of the procedures established by this plan. All on-site personnel must be completely familiar with these procedures to ensure proper response to an emergency.

2. Fire Prevention Procedures. The procedures listed below are to be followed in an effort to reduce chances of an uncontrolled fire. Three portable fire extinguishers will be at the test site, and all personnel participating in the fire test will be briefed on the locations and proper use of the extinguishers.

E. TEST SITE LOCATIONS

All fire tests will be conducted at the 100-foot AFESC Fire Research Facility 1, located on Farm Dale Road. These tests be conducted in accordance with AFESC Office Instruction dated 7 April 1988, titled "Live Fire Demonstration/Tests."

F. NOTIFICATION

Before conducting a fire test, notify the Fire Department Communications Center at Extension 3-2884.

1. The Communications Center will be requested to notify the following:

a. Command Post - 3-2155
b. Air Traffic Control Tower - 3-4553
c. Base Hospital - 3-7514
d. Security Police - 3-2028
e. Division of Forestry - 3-2641
f. Base Weather - 3-2856

2. The Fire Department Communications Center will need an estimate of the duration of the live fire tests.

CHECKLIST

TO BE USED BEFORE CONDUCTING FIRE TESTS AT

FIRE RESEARCH FACILITY 1

DATE:_____ TIME:_____

VERIFIED	PROCEDURES
___	Brief all personnel on proper safety procedures.
___	All personnel at the test site are required for the test or are an approved visitor?
___	Brief all personnel on accident and fire reporting procedures.
___	Radio or telephone communications available?
___	Post telephone numbers for the ambulance and fire department by the telephone or radio.
___	Ensure that adequate first aid kit is available.
___	Ensure that an emergency eye wash station is available.
___	Ensure that all fuel valves are closed and that there are no fuel leaks prior to fuel ignition.
___	Secure area prior to igniting fire.

ANNEX 4

FIREFIGHTING VEHICLE FLUID CALIBRATION PROCEDURES

A. WATER TANK

1. Ensure that water tank is empty.

2. Ensure that the vehicle is parked on a level surface throughout tank calibration procedures.

3. Using a liquid flow meter, fill tank in 50 gallon increments, to its 1,000 gallon capacity, and calibrate a tank level indicator (dip stick) at 50 gallon increments.

DATA SHEET

WATER TANK

Date:_____ Vehicle Registration Number:_____

Test Conductors:_____ _____

Fill Point	Water Gallons	Water Depth
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
6	_____	_____
7	_____	_____
8	_____	_____
9	_____	_____
10	_____	_____
11	_____	_____
12	_____	_____
13	_____	_____
14	_____	_____
15	_____	_____
16	_____	_____
17	_____	_____
18	_____	_____
19	_____	_____
20	_____	_____

B. AFFF TANK

1. Ensure that AFFF tank is empty.

2. Ensure that the vehicle is parked on a level surface throughout tank calibration procedures.

3. Using a liquid flow meter, fill AFFF tank in 5 gallon increments, to its 130 gallon capacity, and calibrate a tank level indicator (dip stick) at 5 gallon increments.

DATA SHEET

AFFF TANK

Date:_____ Vehicle Registration Number:_____

Test Conductors:_____ _____

Fill Point	Water Gallons	Water Depth
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
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23		
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25		
26		

ANNEX 5

AFFF METERING TEST MATRIX

AND DATA COLLECTION SHEET

TEST NO.	TURRET	AFFF TANK	DISPENSING TIME (sec)	WATER TANK START	WATER TANK END	AFFF TANK START	AFFF TANK END	WATER USED	AFFF USED	RATIO	AMB. TEMP	TEST DATE
1	ROOF	WATER	60									
2	ROOF	WATER	60									
3	ROOF	AFFF	60									
4	BUMPER	WATER	60									
5	BUMPER	WATER	60									
6	BUMPER	AFFF	60									
7	HANDLINE	WATER	120									
8	HANDLINE	WATER	120									
9	HANDLINE	AFFF	120									
10	ROOF/BUMP	WATER	30									
11	ROOF/BUMP	WATER	60									
12	ROOF/BUMP	AFFF	30									

ANNEX 6

LARGE-SCALE FIRE TEST PIT OPERATIONAL PROCEDURES

The following procedures are to be used during the operation of the 100-foot fire test pit and the Large-scale fire tests:

TEST PROCEDURES:

1. Pump 500 gallons of fuel into the test pit either directly from the fuel storage tanks or from the fuel truck through the fuel manifold.

2. Verify that all fuel valves are closed and that there are no leaks or spills in the fuel system.

3. After verifying that all data collection, video, and safety precautions are ready, proceed with fuel ignition upon direction from the test director.

CAUTION: PROCEED WITH FUEL IGNITION ONLY AFTER DIRECTED BY THE TEST DIRECTOR.

4. At the JP-4 storage area, turn "ON" the IGNITION SWITCH and leave ON until the fuel in the burn area ignites. Turn switch "OFF" once ignition occurs.

5. Allow a 30 second preburn.

6. Drive the P-19 to within 15 feet of the fire pit.

7. Start timer.

8. Aggressively extinguish fire.

9. Record time required to extinguish fire.

10. Record fire crash vehicle pumping parameters: rpm, pressure, etc.

POST TEST PROCEDURES:

After the fire has been extinguished, proceed with the following steps:

1. At the ELECTRICAL SERVICES SHELTER, turn "OFF" the IGNITER LOCKOUT SWITCH and ALL IGNITER TOGGLE SWITCHES.

2. Slowly "OPEN" the PIT WASHOUT DRAIN VALVE at the oil separator. TWO TURNS to begin draining the burn area.

3. Turn "ON" separator outlet pumps P6B and P6C and verify flow to the effluent holding pond.

4. Turn "ON" PIT WASHDOWN PUMP P4 and allow to run until it automatically turns off. The pump is controlled by a preset timer and will turn off after 9 minutes.

5. As the effluent flows to the separator, adjust the flow using the PIT WASHOUT DRAIN VALVE until the unburned fuel skims into the reburn skimmer barrel.

6. Allow Pumps P6B and P6C to run to the low level cutoff. The water level in the first stage of the oil/water separator should be at the bottom edge of the oil separator concrete inlet slab in the first stage when the low level cutoff occurs.

7. "RECORD" the number of gallons of fuel used from the resetable counter and the fixed counter fuel meter reading on the OPERATIONS CHECK SHEET. These readings are on the fuel meter at the JP-4 fuel storage pit.

8. Turn "ON" SEPARATOR TO STORAGE PUMP P2 and pump the unburned fuel from the skimmer drum to the storage tank at the oil separator. Turn "OFF" Pump P2 when the top of the foot valve just becomes visible. DO NOT attempt to pump all the fuel from the barrel. Further pumping will result in the loss of the prime for the P2 PUMP. To prime, see the note below.

NOTE: SHOULD THE PRIME IN THE SEPARATOR TO STORAGE PUMP P2 BE LOST, (1) TURN OFF PUMP, (2) REMOVE THE PIPE PLUG FROM THE PIPE TEE IN THE SUCTION LINE, (3) FILL PIPE WITH WATER THROUGH THE TEE, (4) THEN REINSTALL THE PIPE PLUG.

9. "RESET" the fuel meter counter to zero.

10. "COMPLETE" the OPERATIONS CHECK SHEET recording the fuel used and the other required operations information.

11. Replenish fuel tank for next test. See Pre-Test Instructions.

12. Measure and record water level in P-19 tank.

13. Proceed with preparations for the next test.

After the last test for the day, complete the following action:

FACILITY SHUTDOWN:

NOTE: COMPLETE THIS SECTION OF THE PROCEDURES WHEN ALL FIRE HAS BEEN EXTINGUISHED AND ALL FIRE TESTS HAVE BEEN TERMINATED.

1. "CLOSE" the FUEL PUMP ISOLATION VALVE between the fuel pump and fuel tank.

2. Turn "OFF" all DISCONNECT SWITCHES at the ELECTRICAL SERVICES SHELTER.

3. Notify the fire department that testing has been completed.

4. Secure and lock the gates and facility switches as required.

LARGE-SCALE FIRE TEST

TEST CONDUCT AND DATA COLLECTION CHECKLIST

TEST NO._____ DATE: _____ TIME: _____

P-19 FIRE-FIGHTING VEHICLE DATA:

FOAM MANUFACTURER:_____ LOT #:_____ MIXTURE RATIO:_____

INITIAL QUANTITY:_____ gal.

AFFF TANK LEVEL - INITIAL: _____ inches FINAL: _____ inches

WATER TANK LEVEL - INITIAL: _____ inches FINAL: _____ inches

CALCULATED MIXTURE RATIO: _____ AGENT FLOW RATE: _____ gpm

APPLICATION DENSITY: _____ GAL/FT^2

METEOROLOGICAL DATA:

TEMPERATURE: _____ PRESSURE:_____ WIND: _____

TEST READINESS:

_____ Weather within limits _____ Communications check

_____ Fire trucks operational _____ Ignition system ready

_____ Video cameras ready _____ Fuel in pit

_____ Emer. Medical notified _____ Access gate secured

CLEARANCE FOR IGNITION:

_____ Safety Officer _____ Fire Department

IGNITION TIME: _____

FOAM APPLICATION: START: _____ END: _____

EXTINGUISHING TIME: _____ sec.

COMMENTS:

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